

Semiconductor Device and Resin Binder for Assembling Semiconductor Device

TECHNICAL FIELD

The present invention relates to a semiconductor device provided with a plate
5 bonded to a back surface of a semiconductor element for protection of the
semiconductor element.

BACKGROUND OF THE INVENTION

As a mounting structure of electronic component manufactured with a
10 semiconductor element in a form of package to be mounted to a circuit board,
there is a known structure in which protruding electrodes such as solder bumps
are formed on the electronic component and connected to the circuit board. In
any such mounting structure, it is necessary to reduce a magnitude of thermal
stress during heat cycle testing in order to ensure reliability of bonding after the
15 mounting. In other words, it is essential to reduce the thermal stress developed
in the bonded areas between the semiconductor element and the solder bumps
caused by changes in the surrounding temperature after the mounting due to a
difference in coefficient of thermal expansion between the semiconductor
element and the work.

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SUMMARY OF THE INVENTION

The present invention is intended to provide a semiconductor device having an
outstanding on-board mounting reliability. The semiconductor device comprises
a plate bonded to a back surface of a thin semiconductor element in which a
25 thickness of a bonding layer is adjusted to be within a predetermined range.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is a perspective view of a semiconductor device according to a first exemplary embodiment of the present invention.

Fig. 1B is a sectional view showing a part of the semiconductor device of the first exemplary embodiment of the invention.

5 Figs. 2A through 2C are sectional views showing parts of the semiconductor device of the first exemplary embodiment of the invention.

Figs. 3A through 3E are diagrammatic illustrations representing a method of assembling the semiconductor device of the first exemplary embodiment of this invention.

10 Fig. 4 is a perspective view showing a plate-like member used in the semiconductor device of the first exemplary embodiment of this invention.

Fig. 5 is a perspective view of an electronic component mounting apparatus used for assembling the semiconductor device of the first exemplary embodiment of this invention.

15 Fig. 6 is a perspective view of a dicing apparatus used for assembling the semiconductor device of the first exemplary embodiment of this invention.

Fig. 7 is a sectional view of a portion of the dicing apparatus used for assembling the semiconductor device of the first exemplary embodiment of this invention.

20 Fig. 8 is a graphical representation showing a result of simulation for number of life cycles against thermal fatigue (-40°C to 125°C) on the semiconductor device of the first exemplary embodiment of this invention.

Fig. 9A is a perspective view of a semiconductor device according to a second exemplary embodiment of this invention.

25 Fig. 9B is a sectional view showing a part of the semiconductor device of the second exemplary embodiment of this invention.

Fig. 10A is a sectional view of a base plate bonding apparatus according to a

third exemplary embodiment of this invention.

Fig. 10B is a plan view of the base plate bonding apparatus of the third exemplary embodiment of this invention.

5 Figs. 11A through 11C are diagrammatic illustrations showing a method of manufacturing a semiconductor device according to the third exemplary embodiment of this invention.

Figs. 12A through 12C are diagrammatic illustrations also showing the method of manufacturing a semiconductor device according to the third exemplary embodiment of this invention.

10 Figs. 13A through 13C are diagrammatic illustrations also showing the method of manufacturing a semiconductor device according to the third exemplary embodiment of this invention.

DETEAILED DESCRIPTION

15 We made some attempts to produce a semiconductor element with as small a thickness as possible for the purpose of minimizing thermal stress developed in bonded areas between the semiconductor element and solder bumps.

In Japanese Patent Unexamined Publication, No. 2002-141439, the applicants of this patent disclosed a new semiconductor device packaged with a thinly
20 processed semiconductor element. As this semiconductor device comprises a plate (i.e. a structural member) bonded to a back side of the semiconductor element with resin binder, it has such advantages as easy to handle and improving reliability of the bonding at the same time by allowing deformation of the semiconductor element itself and distributing stress in the bonded areas.

25 Since thickness of a bonding layer of resin binder appears to influence greatly upon on-board mounting reliability of the semiconductor device of the above structure, we made studies in an attempt to determine correlation between

thickness of the bonding layer and the on-board mounting reliability. It was found as a result that there is a tendency that the reliability improves as thickness of the bonding layer increases within a specific range when the bonding layer is relatively thin, and that the reliability decreases when the bonding layer exceeds a certain thickness. It was therefore determined effective to adjust the bonding layer to a proper thickness to achieve as much reduction of thickness as feasible of the completed semiconductor device while ensuring the on-board mounting reliability at the same time.

10 (First Exemplary Embodiment)

Referring now to Fig. 1 through Fig. 8, description will be provided of the first exemplary embodiment.

Described first pertains to a semiconductor device. In Figs. 1A and 1B, semiconductor device 1 has a structures in which plate 4 (i.e. a structural member) for protection of semiconductor element 2 is bonded to a back surface of semiconductor element 2 with resin binder 5 of a predetermined thickness. A plurality of bumps 3 are formed on electrodes 2a provided along a fringe on a surface of semiconductor element 2 to serve as terminals for external connections.

20 Semiconductor element 2 shown here is in a shape after it has been subjected to a thinning process by such methods as machine grinding and etching. When the semiconductor element is mounted to a circuit board via the bumps, bonding reliability after the mounting becomes superior in general as the thickness of the semiconductor element is smaller. This is because semiconductor element 2 itself deforms (or bends) in a direction of its thickness and distributes stress caused by a difference in the thermal stress between semiconductor element 2 and the circuit board even though the stress is apt to concentrate on the bonded

areas of bumps 3. For this reason, this exemplary embodiment employs a thinning process of semiconductor element 2 to control its thickness "t1" to be 100 μ m or smaller, thereby making it capable of deforming (bending) in the direction of its thickness.

5 The thinning process includes a rough cutting process made on the back side of a circuit-carrying surface of semiconductor element 2 by machine grinding using a grindstone and the like, and a finishing process by dry etching or wet etching with chemical liquid. The machine grinding produces a damaged layer in which a great number of microcracks are formed on the back surface. Since
10 this damaged layer becomes a main factor in decreasing a flexural strength of the semiconductor element, the finishing process removes the damaged layer and increases the flexural strength of semiconductor element 2.

Plate 4 has a function of protecting semiconductor device 1 from external forces after it is mounted to a circuit board or the like, beside the purpose of
15 making semiconductor device 1 steadily retainable during handling when it is being mounted. Therefore, the plate 4 used here is made of a structural material such as metal, ceramic and plastic in a shape which can satisfy the above functions. In other words, it is fabricated into thickness of "t3" to obtain sufficient strength and rigidity to withstand the external forces, and an external
20 shape larger than that of semiconductor element 2.

The bonding layer comprising resin binder 5 used here between semiconductor element 2 and plate 4 shall be a material that provides for not only adhesion to bond semiconductor element 2 and plate 4, but also a property to satisfy the above functions. In other words, it is required to have the property, which
25 assures strength of semiconductor device 1 by bonding semiconductor element 2 and plate 4 with necessary and sufficient adhesion, and allows as much deformation of semiconductor element 2 as possible into the direction of its

thickness. In semiconductor device 1 illustrated in this first exemplary embodiment, therefore, the resin layer formed of resin binder 5 is made to be easily deformable by adjusting a modulus of elasticity to 10,000Mpa or less, as will be described later. In addition, a thickness of the bonding layer for bonding semiconductor element 2 and plate 4 is adjusted to the proper thickness of "t2" which is described hereinafter.

Thickness "t2" of the bonding layer is set to be a value within a range of 25 μ m to 200 μ m based on a result of numeric simulation (described later) made by the finite element method on a relation between thickness of the bonding layer and number of life cycles. Resin binder 5 as will be described next having the thickness "t2" adjusted within the above-said range allows semiconductor element 2 to deform in a manner to follow deformation of a circuit board when semiconductor device 1 is mounted to the circuit board, so as to ensure outstanding on-board mounting reliability.

Description is provided here of the numeric simulation with reference to Fig. 8.

Fig. 8 shows correlation between thickness "t2" of the bonding layer in the semiconductor device and number of life cycles, when the semiconductor device is mounted to a circuit board and subjected to repeated application of stress corresponding to thermal stress in the actual working condition. The axis of abscissas represents thickness (in mm) of the bonding layer and the axis of ordinates represents number of life cycles. Three different zigzag lines shown in Fig. 8 represent results of the simulation for number of life cycles against thermal fatigue (-40°C to 125°C) when modulus of elasticity of resin binder 5 is adjusted to (1) 400Mpa, (2) 10,000Mpa and (3) 27,500Mpa respectively.

As is obvious from Fig. 8, the larger it is to allow deformation of the semiconductor element with lower modulus of elasticity of the bonding layer, the larger the number of life cycles and the superior in reliability. In any of these

results of simulation, the semiconductor device exhibits a tendency of increasing the life cycles sharply as the thickness of the bonding layer increases within a range of 0.05mm or smaller. The number of life cycles then remains at generally a constant level in a range of the thickness up to about 0.2mm, and the number of life cycles decreases steeply when the thickness increases beyond 0.2mm or thereabout.

When the above results of simulation are interpreted from a practical point of view, they suggest that the semiconductor device of excellent on-board mounting reliability can be obtained by selecting a material of the bonding layer so that its modulus of elasticity becomes 10,000Mpa or less, and setting a thickness of the bonding layer to a value in a range of 0.025mm (25 μ m) to 0.2mm (200 μ m). In manufacturing the semiconductor device, therefore, this exemplary embodiment uses resin binder 5 having a modulus of elasticity of 10,000Mpa or less, and employs the fabricating method capable of adjusting the bonding layer accurately to the thickness of 0.025mm or larger but 0.2mm or smaller.

Description is now provided of resin binder 5. As shown in Fig. 1B, resin binder 5 has a composition comprising a resin component such as epoxy resin as a main constituent with addition of granular filler 9 of inorganic material or resin. Filler 9 has two functions at the same time. They are (1) the fundamental function of the filler for providing the bonding layer with a desired characteristic (i.e. modulus of elasticity) after the resin binder 5 is formed into a bonding layer, and (2) a function as a spacer placed between semiconductor element 2 and plate 4 to provide the bonding layer with a predetermined thickness.

To achieve the above object, filler 9 consisting of a combination of two materials, first filler 9a and second filler 9b, is mixed into resin binder 5 at a ratio of 30 percents or less by weight.

First filler 9a for providing the function of the above-said spacer consists of particles having diameter "d" which is generally equal to the target thickness "t2" of the bonding layer in the semiconductor device, and that the diameter "d" refers to a diameter of largest particles of filler 9 contained in resin binder 5. In other words, first filler 9a contains particles of the largest diameter in resin binder 5, and this diameter "d" is generally equal in dimension to the predetermined thickness of the bonding layer. Second filler 9b is an aggregate of smaller size fillers than the diameter "d" of first filler 9a, and it is so selected as to have a suitable particle size distribution for accomplishing the fundamental function as the filler.

When semiconductor element 2 is placed on plate 4 via resin binder 5 containing first filler 9a and pressed against plate 4 with a predetermined pressure, first filler 9a of the largest diameter particles among the fillers in resin binder 5 come into contact to the back surface of semiconductor element 2 as well as a surface of plate 4, and sandwiched therebetween, as shown in Fig. 2A. This consequently makes the bonding layer into thickness "t2" which is generally equal to the diameter "d" of first filler 9a.

With semiconductor element 2 mounted in position via resin binder 5, however, there may be cases in which first filler 9a remains not in contact directly with any of semiconductor element 2 and plate 4, while a portion of resin layer 501 lies interfering as shown by arrows in Fig. 2B. Such an interference of resin layer 501 can occur (1) if a value of the pressure set for the mounting process is somewhat smaller than necessary to obtain the condition of sufficient contacts, (2) when resin binder 5 flows into interfaces of the contact areas during a hardening process after the mounting, even though first filler 9a once came into contact with any of semiconductor element 2 and plate 4 by the pressure, and (3) if a method adopted for making first filler 9a into contact is not compression, but

other means of softening resin binder 5 when mounting the semiconductor element. Even in these cases, however, the bonding layer serves its intended function as a spacer because a thickness of it is nearly equal to the diameter of first filler 9a.

5 The percentages of first filler 9a and second filler 9b in resin binder 5 and particle size distribution of second fillers 9b are so determined and the products so controlled as to ensure that resin binder 5 positively accomplish the spacer function as well as the fundamental function as the filler. In other words, the percentage of content of first filler 9a is determined so that at least one particle
10 of first filler 9a is included in the bonding layer of each semiconductor device, and resin binder 5 is thoroughly stirred to distribute the filler uniformly before using it. In addition, the particle size distribution and the percentage of content of second filler 9b are adjusted so that it contains particles of the optimum sizes at the optimum ratio of mixture, as shown in Fig. 2C, to satisfy the desired
15 mechanical characteristic as well as heat conductive characteristic, so as to accomplish the fundamental function as the filler.

Inorganic material for use as filler 9 includes such substances as alumina, nitride aluminum and nitride silicon, which are less expensive, yet superior in the ability of heat dissipation. It is also suitable to use granular resin as first
20 filler 9a, when more strict control is desired for the thickness of the bonding layer since its particle size is easy to control. Resin filler, if used as first filler 9a, can avoid an excessive increase in hardness and embrittlement of the bonding layer as is the case when it contains inorganic material of hard property. The resin filler also has an advantage of good affinity with resin binder 5.
25 Besides, there is a potential risk of high pressure concentration in points of contact between first filler 9a and semiconductor element 2 due to the compression during the mounting process, which can be a cause of damage to

the thin semiconductor element. However, when first filler 9a is formed of a polymeric material having good plasticity, its cushioning effect can alleviate the excessive increase of pressure in the points of contact.

Resin binder 5 is pushed out of four side edges around semiconductor element 2, as shown in Fig. 1. The pushed-out portion of resin binder 5a rises up along side edges 2b of semiconductor element 2, and it settles into such shape as to partially cover side edges 2b. This portion of resin binder 5a covering the side edges 2b has an effect of reinforcing the edges of semiconductor element 2. In other words, semiconductor element 2 is liable to bearing small cracks around its edges as they are developed during a cutting process in which a semiconductor wafer is diced into individual pieces of semiconductor element 2, and these cracks can be a cause of damage. When resin binder 5a stays covering side edges 2b, it can reinforce the edges of semiconductor element 2 bearing such small cracks. Furthermore, when temperature of semiconductor device 1 rises while it is mounted to circuit board 10, a difference in thermal deformation between the circuit board and semiconductor element 2 produces stress which tends to deform semiconductor element 2 substantially. Resin binder 5a covering side edges 2b provides the function of preventing any such excessive deformation.

Referring to Fig. 3, described next pertains to a method of assembling semiconductor device 1. In Fig. 3A, plate-like member 6 is an intermediate component before it is cut into plates 4 to compose a part of semiconductor device 1. As shown in Fig. 4, plate-like member 6 is provided with raised partitions 6a in a lattice shape on an upper surface thereof. Recessed portions 6b enclosed by partitions 6a serve as semiconductor bonding areas where semiconductor elements 2 are bonded. Partitions 6a serve as dam barriers for preventing resin binder 5 from spreading over beyond the semiconductor

bonding areas when resin binder 5 is applied inside recessed portions 6b for bonding semiconductor elements 2.

Plate-like member 6 is also provided with grooves 6c formed in positions on the underside surface corresponding to partitions 6a. Plate-like member 6 has a thickness equal to thickness "t3" of plate 4. Grooves 6c are formed by cutting lattice-patterned grooves from the underside of plate-like member 6, so as to provide thin portions having smaller thickness "t4" than "t3" as measured from the upper surface. The thin portions correspond to cutting lines where plate-like member 6 is diced and separated into individual plates 4.

Resin binder 5 is then applied to recessed portions 6b in plate-like member 6 with dispenser 7, as shown in Fig. 3B. Resin binder 5 supplied here is to form the bonding layers where semiconductor elements 2 are bonded. Since partitions 6a are provided around recessed portions 6b, resin binder 5 is prevented from spreading around beyond the semiconductor bonding areas during application of resin binder 5. Resin binder 5 is so adjusted that it contains at least one particle of first filler 9a when coated in each of recessed portions 6b.

During the application, resin binder 5 of an appropriate amount corresponding to the above-said thickness "t2" of the bonding layer, neither too much nor too little, is discharged from dispenser 7, so that it properly covers side edges 2b of semiconductor element 2, as described previously, when it is pressed after the application with semiconductor element 2, in a manner to spread outward beyond the side edges of semiconductor element 2.

After resin binder 5 is applied, plate-like member 6 is transferred to a semiconductor bonding process. In this semiconductor bonding process, semiconductor element 2 is put on resin binder 5 applied to plate-like member 6, and resin binder 5 is subsequently heated to harden thermally, as shown in Fig.

3C and 3D. During this process, the plurality of aligned semiconductor elements 2 are bonded on their back sides to the individual recessed portions 6b of plate-like member 6 with resin binder 5.

Referring to Fig. 5, description is provided of an electronic component mounting apparatus used for mounting semiconductor elements 2. In Fig. 5, component supply table 11 is provided with adhesive sheet 12 carrying semiconductor elements 2 arranged in a lattice pattern. There is semiconductor separating mechanism 13 disposed below component supply table 11. Semiconductor separating mechanism 13 is driven by semiconductor separating mechanism driver 14. When mounting head 16 picks up one of semiconductor elements 2, ejector pin mechanism 13a pushes up the lower side of adhesive sheet 12 to separate semiconductor element 2 from the upper surface of adhesive sheet 12.

Base plate holder 15 is located next to component supply table 11, and base plate holder 15 holds plate-like member 6 bearing the resin binder supplied to it. There is mounting head 16 disposed above component supply table 11 and base plate holder 15, and it is driven by mounting head actuator 19. Mounting head 16 is provided with suction nozzle 8, which picks up semiconductor element 2 from adhesive sheet 12, and mounts it to plate-like member 6 on base plate holder 15.

There is also camera 17 positioned above component supply table 11 for taking an image of semiconductor element 2 adhered to adhesive sheet 12. Semiconductor recognition unit 20 performs a recognition process on the image taken by camera 17 to recognize a position of semiconductor element 2 on adhesive sheet 12. A result of the position recognition is sent to control unit 21 and semiconductor separating mechanism actuator 14. As a result, suction nozzle 8 and ejector pin mechanism 13a are aligned in position to semiconductor

element 2 to be picked up when using mounting head 16 to pick up semiconductor element 2.

Another camera 18 is located above base plate holder 15, and it takes an image of plate-like member 6 held by base plate holder 15. Mounting position
5 recognition unit 22 performs a recognition process on the image taken by camera 18 to perceive a mounting position of the semiconductor element in plate-like member 6. A result of the position recognition is sent to control unit 21. Control unit 21 controls mounting head actuator 19 according to this result of position recognition to align position of semiconductor element 2 held by suction
10 nozzle 8 when semiconductor element 2 is being mounted by mounting head 16.

When mounting semiconductor element 2 onto plate-like member 6 with this electronic component mounting apparatus, suction nozzle 8 sucks and hold semiconductor element 2 on its surface where bumps 3 are formed, as shown in Fig. 3C, and presses the back surface of semiconductor element 2 against resin
15 binder 5. A proper pressure is used to press semiconductor element 2 against plate-like member 6 during this process to form the bonding layer between semiconductor element 2 and plate-like member 6 into thickness "t2" of generally equal dimension as diameter "d" of first filler 9a contained in resin binder 5 (refer to Fig. 2A).

20 The above process of pressing causes a portion of resin binder 5 to flow out around side edges of semiconductor element 2 (refer to arrow A) and rises up along side edges 2b of semiconductor element 2 to cover the side edges 2b (refer to resin binder 5a shown in Fig. 1B). Resin binder 5 serves its purpose when it covers and reinforces throughout the edges of only the back side of
25 semiconductor element 2, since the dicing process is likely to leave damages only in the back side edges. It is therefore appropriate to cover the side edges 2b either completely or partially.

Since semiconductor elements 2 are mounted one after another by being pressed against resin binder 5 with mounting head 16, a mounting load (i.e. pressing force) can be reduced in this exemplary embodiment, as compared to other cases in which a group of semiconductor elements 2 are mounted (adhered) at once. This allows flexibility of selecting any of die-bonding apparatus, a chip moun-
5 ter, and the like as the electronic component mounting apparatus.

Plate-like member 6 thus equipped with semiconductor element 2 is transferred to a heating furnace. Resin binder 5 is thermally hardened as shown in Fig. 3D when it is heated to a predetermined temperature in the heating furnace. During this process of hardening, the flow-out portion of resin
10 binder 5 rises further along side edges 2b of semiconductor element 2 due to the effect of surface tension since its viscosity decreases temporarily, and it is then hardened into a shape to cover the side edges 2b. Accordingly, resin binder 5a is formed as a reinforcing rim in a shape shown in Fig. 1B once resin binder 5 is
15 hardened.

In the above exemplary embodiment, description is given of the example in which resin binder 5 is thermally hardened in the heating furnace after semiconductor element 2 is mounted to plate-like member 6. However, the heating furnace may be replaced with mounting head 16 having a built-in heating means so that plate-like member 6 can be heated while mounting
20 semiconductor element 2.

The separate heating process shown in Fig. 3D can be omitted when mounting head 16 is used for the heating. This provides for an advantage of omitting the heating furnace and simplifying the equipment. In this case, however, the entire productivity may be decreased when compared with the above example in
25 which the mounting process and the heating process are carried out separately, because the cycle time of mounting head 16 is constrained by duration of the

hardening time. In addition, although the above example of this exemplary embodiment indicates use of a thermosetting material as resin binder 5, it can be replaced with thermoplastic resin material.

After resin binder 5 is thus hardened, plate-like member 6 bearing semiconductor elements 2 is transferred to a cutting process, where it is cut with rotary cutting blade 24a along the cutting lines between adjoining semiconductor elements 2, as shown in Fig. 2E. This process cuts and separates plate-like member 6 into plates 4 with individual semiconductor elements 2, to complete assembly of semiconductor devices 1.

This cutting process is further described with reference to Fig. 6 and Fig. 7. Fig. 6 shows a dicing apparatus used for this cutting process. Upon completion of mounting semiconductor elements 2 and hardening the resin binder, plate-like member 6 is placed on plate fixing table 23. Cutting heads 24 provided with rotary cutting blades 24a are arranged above plate fixing table 23. While rotary cutting blades 24a are driven into rotation, cutting heads 24 are moved in the X-direction and the Y-direction to cut plate-like member 6 along cutting lines corresponding to grooves 6c.

Suctioning retainers 25 are arranged on the upper surface of plate fixing table 23, one at each position corresponding to semiconductor element 2 on plate-like member 6. Suctioning channel 25a is formed in the upper surface of each suctioning retainer 25, as shown in Fig. 7. Suctioning channel 25a is in communication with suctioning hole 23a provided inside plate fixing table 23, and suctioning hole 23a is connected to vacuum suctioning source 26. Plate-like member 6 is sucked and held by suctioning retainer 25 to remain fixed in position when vacuum suctioning source 26 is operated with plate-like member 6 placed on its backside in contact with suctioning retainer 25.

Rotary cutting blades 24a are then aligned in positions above partitions 6a of

plate-like member 6, which is held fixed to its position as described, so that plate-like member 6 is cut along thin portions inside grooves 6c when rotary cutting blades 24a are lowered while being rotated. Each rotary cutting blade 24a used for this process has a width of blade smaller than a space between adjoining semiconductor elements 2, so as to cut plate-like member 6 into separate pieces in such a shape that the perimeter of plate 4 extends beyond the side edges of semiconductor element 2. Accordingly, an external size of plate 4 is larger than that of semiconductor element 2 after it is separated into individual pieces as semiconductor devices 1.

In this cutting process, a thickness to be cut through by rotary cutting blades 24a is small because grooves 6c are formed beforehand in the underside surface of plate-like member 6. This can reduce to the utmost an amount of downward movement required in the cutting process of rotary cutting blades 24a, and prevent an incident of a tip of the cutting blade coming into contact to plate fixing table 23 and damaged when the cutting blade is moved downward.

In this exemplary embodiment, although description is given of resin binder 5 of paste form, it can be resin adhesive of a sheet form or a tape form, which can be used in such a manner that it is placed on either of plate-like member 6 or semiconductor element 2 to bond them together.

(Second Exemplary Embodiment)

Description is provided now of a semiconductor device of the second exemplary embodiment of this invention with reference to Fig. 9A and Fig. 9B.

In Fig. 9A, semiconductor device 1B has a structure in which plate 4 (i.e. a structural member) is bonded to a back surface of semiconductor element 30 having a re-wiring layer with a bonding layer of the same resin binder 5 as the first exemplary embodiment. Semiconductor element 30 having re-wiring layer

is provided with a plurality of bumps 3 formed into a lattice pattern on a surface thereof. Semiconductor element 30 having re-wiring layer has a structure as shown in Fig. 9 B in which re-wiring layer 29 is formed on the surface (i.e. one of the surfaces where electrodes are formed) of semiconductor element 2A which
5 has undergone a thinning process in the same manner as semiconductor element 2 described in the first exemplary embodiment.

Electrodes 2a serving as terminals for external connections are formed along a fringe on a surface of semiconductor element 2A, and each of electrodes 2a is electrically connected through internal wiring 29b to corresponding one of
10 electrodes 29a formed in the same number as electrodes 2a on the surface of re-wiring layer 29. Electrodes 29a bear bumps 3 formed thereon for mounting of semiconductor device 1B. This semiconductor device 1B can be assembled by simply substituting semiconductor element 2 with semiconductor element 30 having the re-wiring layer in the method of assembling semiconductor device
15 discussed in the first exemplary embodiment.

This produces flow-out of resin binder 5a around side edges 30a of semiconductor element 30 carrying the re-wiring layer, and forms a reinforcing rim to cover the side edges 30a. In semiconductor device 1B of such structure, the reinforcing rim formed to cover side edges 30a of semiconductor element 30
20 carrying the re-wiring layer can prevent bending and deformation developed in the edges of semiconductor element 30 after the mounting, and avoids internal wirings 29b inside re-wiring layer 29 from being broken open.

Resin binder 5 of paste form and sheet form (or a tape form) can also be used in this exemplary embodiment.

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(Third Exemplary Embodiment)

Referring to Fig. 10, Fig. 11, Fig. 12 and Fig. 13, description is provided of a

base plate bonding apparatus of the third exemplary embodiment of this invention.

A structure of the base plate bonding apparatus is described first with reference to Fig. 10A and 10B. This base plate bonding apparatus is used in a process of manufacturing a semiconductor device, which comprises a semiconductor element and a reinforcing member bonded to the backside of an electrode-bearing surface of the semiconductor element on which electrodes for external connections are formed, via resin binder, wherein the apparatus bonds together a semiconductor wafer having a plurality of semiconductor elements constructed thereon with a reinforcing sheet in an original form prior to being cut individually into separate pieces of reinforcing members.

In Fig. 10A, an upper surface of retaining table 31 constitutes wafer retaining space 31a whereon semiconductor wafer 34 is retained. Spacer ring 32 is fixed to wafer retaining space 31a, and semiconductor wafer 34, after subjected to a thinning process using such methods as machine grinding and the like, is placed inside of spacer ring 32. Spacer ring 32 is an annularly shaped fixture which has an inner diameter conforming to an outer diameter of semiconductor wafer 34 as well as that of reinforcing sheet 39 to be bonded. Spacer ring 32 is provided with cutout slits 32a in a plurality of locations on the upper surface thereof. Cutout slits 32a functions as resin discharge gates for draining extra resin binder to the outside during the process of bonding semiconductor wafer 34 and reinforcing sheet 39, as will be described later.

Wafer retaining space 31a inside spacer ring 32 has suctioning holes 31b (refer also to Fig. 10B), which are in communication to first suction unit 35 via suction path 31c. When first suction unit 35 is driven, it draws vacuum from suctioning holes 31b, which suck and retain semiconductor wafer 34 on wafer retaining space 31a. Wafer retaining space 31a, suctioning holes 31b and first

suction unit 35 constitute retaining means of semiconductor wafer 34. Retaining table 31 has built-in heater 33, which heats semiconductor wafer 34 placed on wafer retaining space 31a when electric power is supplied to heater 33 by heater power supply 36.

5 Retaining head 40 is positioned above retaining table 31 in a vertically slidable manner by elevating mechanism 41. An underside surface of retaining head 40 defines sheet retaining surface 40a which retains reinforcing sheet 39. Sheet retaining surface 40a is adjusted of its parallelism so as to maintain it in parallel with respect to wafer retaining space 31a on retaining table 31. Sheet
10 retaining surface 40a has suctioning holes 40b, which are in communication to second suction unit 38 through suctioning path 40c. When second suction unit 38 is driven, it draws vacuum from suctioning holes 40b, which suck and retain reinforcing sheet 39 onto sheet retaining surface 40a. Sheet retaining surface 40a, suctioning holes 40b and second suction unit 38 constitute retaining means
15 of reinforcing sheet 39.

Reinforcing sheet 39 is fabricated of a material such as resin, ceramic and metal into a thin plate of circular shape. It is cut and the individual semiconductor elements separated to form semiconductor devices, so that each functions as a retaining sheet for handling the semiconductor device as well as a
20 reinforcing member for protecting the semiconductor device from external forces and impacts. Accordingly, reinforcing sheet 39 has a thickness needed to keep sufficient strength to protect the thin semiconductor device.

First suction unit 35, second suction unit 38, heater power supply 36 and head actuator 41 are controlled individually by control unit 37. By controlling the
25 components discussed above, control unit 37 executes the bonding process of semiconductor wafer 34 and reinforcing sheet 39, as described hereinafter.

First, semiconductor wafer 34 is positioned inside spacer ring 32 on retaining

table 31, with the circuit-bearing surface facing downward as shown in Fig. 11A, and reinforcing sheet 39 is placed on top of semiconductor wafer 34. Next, retaining head 40 is lowered toward retaining table 31 until it comes in abutment on spacer ring 32, as shown in Fig. 11B. While vacuum is being
5 suctioned through suctioning path 31c to keep semiconductor wafer 34 retained on retaining table 31, vacuum is also suctioned from suctioning path 40c in retaining head 40 to suck and pick up reinforcing sheet 39 from inside of spacer ring 32 onto sheet retaining surface 40a.

When retaining head 40 is subsequently moved upward, reinforcing sheet 39
10 is kept retained on sheet retaining surface 40a of retaining head 40 while semiconductor wafer 34 is retained in wafer retaining space 31a in retaining table 31, as shown in Fig. 11C. Next, resin binder 5 of thermosetting property having the same composition as the first exemplary embodiment is supplied by dispenser 42 to a center area on the surface of semiconductor wafer 34 inside
15 spacer ring 32, as shown in Fig. 12A.

Retaining table 31 is heated by heater 33 during this time. Since the heat temporarily softens the viscosity of resin binder 5, it starts flowing into a bulgy shape with a larger thickness in the center than its periphery on the surface of semiconductor wafer 34. Retaining head 40 is then lowered toward retaining
20 table 31 while still retaining reinforcing sheet 39 on it, as shown in Fig. 12B. That is, after the process of resin supply, semiconductor wafer 34 and reinforcing sheet 39 are moved closer to each other while maintaining their parallel position. In this process, the bottom side of reinforcing sheet 39 comes in contact to resin binder 5, and pushes resin binder 5 to spread.

25 Since resin binder 5 is discharged into the bulgy shape, or a lump of convex form, it is pushed to spread gradually from the center toward the periphery. This process of spreading is quite effective in preventing air from being trapped

inside resin binder 5, so as not to produce voids in it. Further compression of retaining head 40 at a predetermined pressure fills a space between semiconductor wafer 34 and reinforcing sheet 39 completely with the liquefied resin binder 5, as shown in Fig. 12C, and drains extra amount of resin binder 5 to the outside from cutout slits 32a provided in spacer ring 32. Because resin binder 5 contains first filler 9a like that of the first exemplary embodiment, a bonding layer formed of resin binder 5 is kept to a predetermined thickness which is generally equal to the diameter "d" of first filler 9a.

Heater 33 continues to heat retaining table 31 under this condition to advance the heat curing reaction of resin binder 5 in the space between semiconductor wafer 34 and reinforcing sheet 39. This causes resin binder 5 to complete the bonding between semiconductor wafer 34 and reinforcing sheet 39. Resin binder 5 needs not be cured completely during this process of resin-hardening, so long as resin binder 5 is hardened to such a degree that integrated body 44 can maintain the desired shape. In the above example, although semiconductor wafer 34 and reinforcing sheet 39 are retained by retaining table 31 and retaining head 40 respectively, they can be reversed upside down so that resin binder 5 may be supplied onto reinforcing sheet 39 retained on retaining table 31.

Integrated body 44 comprising semiconductor wafer 34 bonded to reinforcing sheet 39 as shown in Fig. 13A is completed when it is removed from spacer ring 32, and this integrated body 44 is transferred next to the dicing process. In other words, integrated body 44 is cut through from the semiconductor wafer 34 side with dicing tool 45 as shown in Fig. 13B, and separated into individual pieces. This completes semiconductor device 46 having plate 39a bonded to semiconductor element 34a, as shown in Fig. 13C.

In the semiconductor device discussed in each of the first, second and third

exemplary embodiments, the bonding layer for bonding between the semiconductor element and the reinforcing plate is formed to be easily deformable by setting its modulus of elasticity to 10,000Mpa or less. In addition, a thickness of the bonding layer is adjusted to the proper range (i.e. 25 μ m or
5 larger, but 200 μ m or smaller) in order to ensure reliability of the semiconductor device after mounted. Furthermore, the resin binder used to form the bonding layer is so arranged as to contain fillers of which particle sizes are controlled to obtain the function of ensuring the proper thickness of the bonding layer. As a result, the invention makes possible to control the thickness of the bonding layer,
10 and to ensure reliability of the semiconductor device after it is mounted, without requiring complicated control in the assembling process of the semiconductor device.

The present invention provides a semiconductor device of outstanding on-board mounting reliability since it comprises a resin bonding layer, of which a
15 thickness can be adjusted to a proper value within a range of 25 μ m to 200 μ m, for bonding a plate to a semiconductor element.